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Analysis of Phenological Protocols in Acadia National Park

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Analysis of Phenological Protocols in Acadia National Park

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Abstract

Changes in the environment have impacted wildlife habitats and caused behavioral changes. In an effort to combat and monitor these changes, complex phenological protocols have been established. The objective of the Near-Field project team was to analyze these protocols and create educational video tutorials for the public and the staff of the National Park Service in Acadia National Park. These tutorials encompass the fundamentals of the hardware and software involved in near-field sound analysis for phenological research.

Executive Summary

Dr. Abe Miller-Rushing, Science Coordinator for Acadia National Park, defined phenology as the study of changes. In this statement he is specifically referring to changes in nature. The natural world is currently undergoing significant ecosystem transformations. For example, climate change is reshaping hundreds of natural landscapes. The National Park Service is doing their best to gain an understanding of how this restructuring will affect wildlife. Researchers working with the Park Service must be up to date in their methods of research in order to fully comprehend these changes.

One example of natural-research techniques, and the focus of this project, is near-field bioacoustics. Bioacoustics utilizes sound recordings to better understand the implications of sounds in nature. The mission of this project was to provide Acadia with a better understanding of bioacoustics and to help simplify near-field, time lapse bioacoustics for researchers. This was accomplished through the implementation of three main objectives. They are as follows:

1. Discover and review the best sound analysis software
2. Practice and review the National Park Service's current Phenology Monitoring Protocol
3. Create video tutorials for near-field bioacoustics procedures

Bioacoustics has been around for centuries. Lewis and Clark completed very primitive bioacoustics research as they explored the Louisiana territory. By simply describing birdcalls and other natural sound emissions on paper, they created a database of basic sounds. As time passed, researchers began to utilize more advanced technology. Sound recorders were taken into the field to record natural signals. This technology allowed for the sounds to be studied in

laboratories and more accurately archived. With the development of computers came the ability to view sound files in a visual format. Waveform and spectrogram plots allowed for amplitude and frequency analysis. Once again, the process for analyzing sound was simplified.

However, problems still existed. Listening to sound files could take hundreds of hours, and visual analysis could prove to be equally time-consuming. More recently, time-lapse technology has been applied to the field of bioacoustics. By controlling the length and time of sound recording, it is possible to record months' worth of data and store it in relatively small files. Sound analysis software is also currently available. Technology and programming have made it possible to locate specific bird songs that may be buried in hundreds of hours of audio data.

The National Park Service created *A Call to Action* for their centennial in 2016. In it, the Service specified several goals to be accomplished in the near future. To complete these goals, specific action points were formed. Several of these relate to this project and bioacoustics. The related action points are listed below:

- Number 21- Establish NPS as leader in addressing climate change
- Number 22- Promote large landscape conservation
- Number 30- Provide employees the tools, training and opportunity to reach a full career potential

The National Park Service can accomplish these action points using near-field bioacoustic analysis. However, bioacoustics is complex. Thus, the process utilized to complete bioacoustics research varies by researcher. To alleviate the issues that stem from variations in techniques, the National Park Service along with several other groups interested in phenological research developed a protocol that outlines a process for researchers. Titled, Phenology

Monitoring Protocol, the report contains over 260 pages of text, graphs, and pictures. It is broken down into thirteen Standard Operating Procedures. The topics of these procedures vary greatly. This project focuses on those that relate to bioacoustics.

To complete the aforementioned objectives, all of these procedures and technologies would need to be incorporated into one project, starting with hardware and software. Acadia National Park currently utilizes the Song Meter SM2+ created by Wildlife Acoustics. Therefore these audio recording devices were conveniently available for use in this project. Both have the ability to view sound files as spectrograms and waveform plots, as well as the capability to sift through hundreds of hours of data to find specific birdcall audio signals. The two programs are Song Scope, also made by Wildlife Acoustics, and Raven Pro 1.4, produced by The Lab of Ornithology at Cornell University. It was important to find out which of these is the most effective at analyzing sounds for researchers using the Song Meter to record in the field.

The second objective relates to the phenology protocol. The protocol has yet to be published and is currently in peer review. To assist the Park in determining the effectiveness of the protocol a few Standard Operating Procedures were selected that relate to bioacoustics. Specifically these procedures relate to the hardware the Park is currently utilizing. These procedures were to be practiced to comprehend their effectiveness and usefulness.

The Phenology Protocol is lengthy, technical, and covers an extensive range of topics. For the researcher who is simply looking for assistance on a small topic of bioacoustics, it is inefficient. A simplification of the Standard Operating Procedures would prove useful for researchers. Therefore, to meet the third objective, it was decided to take the practiced procedures and conceive a way to simplify them into useful and interactive tools. Thus, the concept of video tutorials was developed.

The National Phenology Network had already established several examples of similar video tutorials. Nevertheless, these tutorials were not interactive and did not serve the purpose of simplifying the Phenology Protocol laid out by the Park. They would however be useful models for the creation of the tutorials created for this project. These tutorials could be constructed using off the shelf media production software. Once completed, they were to be presented to Acadia National Park. From here, they could be archived and utilized by future researchers. To further promote accessibility, the tutorials were to be uploaded to the Internet so that researchers and students alike could put them to use.

Following the implementation of these objectives, certain results were ascertained. Raven Pro 1.4 proved very effective as an audio viewing software. There are dozens of commands within the program for audio file analysis. Spectrogram and waveform plot viewing as well as annotating (taking notes on screen) is made easy in Raven Pro, even for someone with novice capabilities. These features would prove invaluable to researchers. Additionally, Raven's ability to identify specific birdcalls through "recognizers", when programmed correctly, proved to be accurate. Clear visual representations of audio files and customization capabilities made Song Scope viable sound analysis software as well. Song Scope excelled in the ability to develop recognizers and detection. Although a complicated process, it is not unmanageable. Once completed, its accuracy is spectacular with very few false positive or missed signals.

Through this project the procedure was found to be intelligible and easily followed. Standard Operating Procedure #6, titled Deployment and Maintenance of Autonomous Recording Units was the focal point of review. This procedure described programming, deploying, and maintaining a Song Meter in the field. This proof of concept through trial showed that simplification of the Phenology Protocol was possible.

Simplification of the Protocol coincides with the final objective. A total of six video tutorials were created covering information spanning Standard Operating Procedure #6 and Raven Pro 1.4. These tutorials accomplished the goal of helping Acadia National Park gain a better understanding of phenological procedures. These tutorials were made accessible via the team's website and YouTube channel. The tutorials as well as the process for their creation were turned over to the Park for future reference. This way, future teams and staffers could continue to make videos that summarize other aspects of the Protocol.

Conclusions and recommendations for this project are as follows. Acadia National Park should continue their review of the Phenology Protocol. From what was seen in this project, the Standard Operating Procedures are sound and can be summarized. However, since only one procedure was examined in depth, more exploration should be completed. If other procedures are easily summarized in the form of tutorials, this process of tutorial creation should be continued. Future software tutorials should focus upon Raven Pro 1.4, since it proved to be the preferred audio viewing software due to both the available features and cost effectiveness. However, a better production environment, such as in house multimedia production studio would greatly assist those creating the videos. Finally, since the tutorials are easily stored on databases such as IRMA (Integrated Resource Management Applications; currently operated by the Park as a data storage facility), they have the ability to assist researchers in the future study of phenology through bioacoustics.

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Chapter 1: Introduction

An increase in population and mechanical transportation methods in the last one hundred years have had a monumental impact on wildlife habitats. Animals are continuously changing their daily habits in an attempt to adapt to these changing environments. The United States National Park Service aims to protect these environments. In order to do this they must first analyze how these environments are being altered.

The National Park Service has employed many methods in the preservation of the nation's ecosystems. These methods have been instrumental in combating environmental changes, which greatly impact the natural landscape and soundscape of various places. In *A Call to Action*, the National Park Service outlined 39 action points to be completed with the intention of connecting people to the parks, advancing education, and preservation. As part of the National Park Service, Acadia National Park is committed to these action points as well.

The mission of this project is to simplify near-field, time-lapse sound analysis for researchers. This mission is attributed to the need for a practical approach to complicated phenological research for park staff and researchers. To do this, three objectives were developed. The first was to discover and review the best sound analysis software. This objective narrows down the pool of available software and makes software feature comparisons easily accessible. The second objective is to practice and review the National Park Service's current Phenology Monitoring Protocol. This objective allows the Protocol to be field-tested. The Protocol is complex and extraordinarily detailed. Once field-tested the Protocol can be simplified making it more accessible and practical. The last objective is to create video tutorials encompassing near-

field bioacoustics recording and sound analysis techniques. This is the culmination of the first two objectives and marks the completion of the project mission.

Upon completion of the project objectives, a comprehensive software comparison will be made available to the Park and the public. This comparison will be further reinforced by the video tutorials, which will highlight software and hardware features and how to easily utilize them. After this, further recommendations can be made for Acadia National Park.

Chapter 2: Background

The National Park Service is fighting a losing battle. Human innovations are causing the environmental order of the Earth to fall out of balance. The Park Service is up against insurmountable odds as it has been charged with the duty of preserving nature. The job of preserving an ever-changing environment may seem impossible; however, it is possible to combat the symptoms. To do this, the Parks must utilize the most modern research techniques for understanding nature. The following sections will discuss a general history of the National Park Service in order to gain a better understanding of their mission and how they are trying to fulfill it. The following sections will examine sound in relation to environmental changes, and the possible solutions that the study of sound presents. Finally, a brief history of how sound is currently used for educational purposes is mentioned.

2.1 The National Park Service

The National Park Service was established in 1916 to further the public's enjoyment of the National Parks and to preserve the final wild frontiers (Sellars 12). The purpose of the National Park Service remains the same today, to preserve nature and make it accessible. However, preservation and accessibility come at a price. To preserve, one must yield accessibility and to achieve accessibility, one must yield preservation. To allow these two principles to coexist, the National Park Service has worked untiringly. The result, in spite of conflict and turmoil, is a sustainable system of parks that the public can enjoy and help protect.

2.1.1 Combating Environmental Changes

The Park Service needs help in order to protect the environment. They utilize two main groups for this assistance. The Park has its own internal division that assists with preservation. The other group is the public who, when educated, can be an invaluable resource for the conservation of the environment.

Each park has vast resources that include everything from historic battlegrounds to natural splendor. Working under the National Park Service to preserve these resources is the Environmental Quality Division. The Environmental Quality Division "coordinate[s] spill response activities, create[s] damage assessments, restore[s] injured park resources, provide[s] social science expertise, and manage[s] reviews of other federal agency actions that could impact park resources" (*NPS*). This Division is actively trying to preserve the National Park system for future use and admiration. Even though this group's primary concern is preservation, resources are also directed towards enhancing public involvement through various projects.

With the National Parks having approximately 280 million visitors each year, there are plenty of people available to help with conservation (*NPS*). A reason for this overwhelming number of park goers is the success the Park Service has had in making the National Parks attractive to visitors. Another reason for this high volume of tourist traffic is increased accessibility. Before arriving, visitors may visit park websites and see what they will encounter. These websites offer an in-depth look at the animals and landscapes of each individual area and the different programs the specific parks offer.

2.1.2 Acadia's Involvement

Acadia National Park is located on Mount Desert Island. This park was the first National Park established east of the Mississippi River. The natural landscape has many features making it "one of the most diverse parks in America" (Kaiser 11). The park includes habitats ranging from forests, and wetlands, to coasts. Many of these features cannot be found collectively anywhere else in the world.

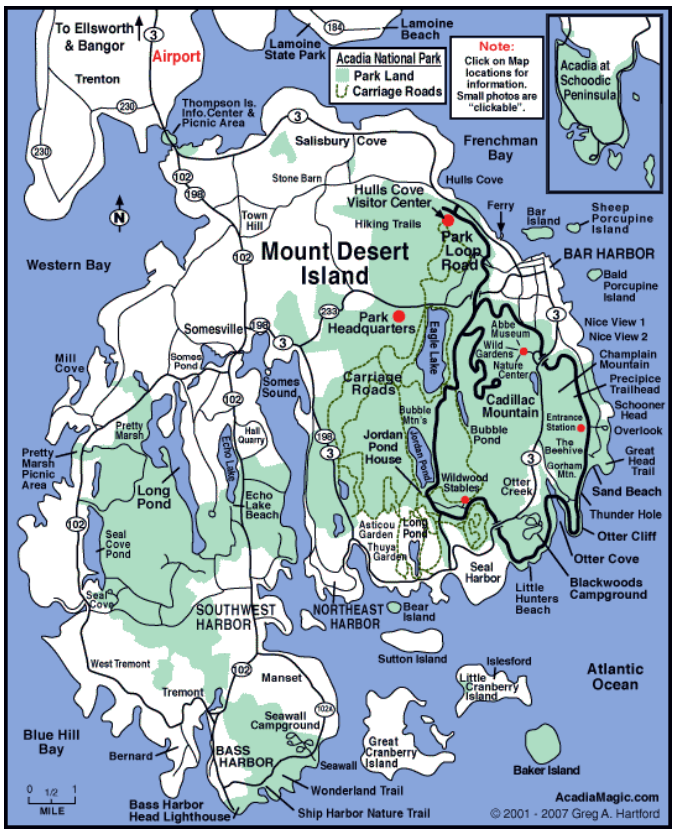


Figure 1 Map of Mount Desert Island

To preserve the natural features, Acadia, has begun to archive and collect samples of animal and plant species inside the park. The rangers, scientists, and students in the park form a group that collaborates to "develop a deep understanding of park resources and the relevance of

parks in their lives" (*NPS*). To develop this understanding, techniques for collecting the data in Acadia's environment must be explored and standardized for widespread use.

Such techniques include methods for recording soundscapes and capturing landscapes. These techniques have been in practice for years allowing many methods to be tried and improved. In Acadia, emphasis has been put on near-field sound analysis for audio preservation and time-lapse photography for visual preservation. These two methods have greatly developed in recent years and can be applied in a variety of environments. Concurrent with these approaches compatible hardware and software have been developed to fit every user's needs. Specifically there are better ways to archive data for reference and analysis thus improving accessibility.

2.2 Phenology

Phenology is the scientific study of periodic biological phenomena in relationship to climatic conditions (*Merriam-Webster*). This field of study has become increasingly relevant in today's changing ecosystems due to climate change and human involvement. As our climates and seasons are changing in different ways, animals and plants are responding with uncharacteristic behavior. Birds and plants are the most sensitive to these changes. Establishing a standardized process to study these new habits has become glaringly apparent (*USANPN*).

The National Park Service, in collaboration with various other organizations, has established a Phenology Protocol to be followed when observing changes in the environment. This protocol will lead the way in studying and recording phenological data.

2.3 Audio Preservation

There are many ways to use audio recordings in nature preservation. Our specific application is in the field of bioacoustics. Bioacoustic recording began in 1889, in Germany, with an Edison Wax Cylinder. Since this original recording, the technology used for animal recording has become more sophisticated. The field of bioacoustics now includes a diverse array of species recordings and a technology repertoire to match.

2.3.1 History of Bioacoustics

The first recorded animals were captive birds. Wild bird recordings followed shortly after. In 1892, recording of captive primates began. The expansion of research from recordings of avian species to those of mammalian species opened the doors to more innovative research. For example, primate recordings were collected and examined by R.L. Garner, a behavioral scientist. In his analysis, Garner realized that sounds captured in the recordings were forms of communication within the primate community, communication such as mating calls, alarms and other signals (Ranft 1).

As a result of these studies, it became apparent that the recordings must be preserved for future research. Kellogg and Allen established archives in the 1950s. Their collection eventually formed the Macaulay Library for Natural Sounds at Cornell University (Ranft 456).

TABLE I

Major natural sound archives (adapted from Alström and Ranft 2003)

Sound library	year established	number of recordings
Macaulay Library of Natural Sounds, Ithaca, USA	1956	150,000
The British Library Sound Archive, London, UK	1969	140,000
Tierstimmenarchiv, Berlin, Germany	1952	100,000
Fitzpatrick Bird Communication Library, Pretoria, South Africa	1979	30,000
Australian National Wildlife Collection, Lyneham, Australia	1961	25,000
Arquivo Sonoro Neotropical, São Paulo, Brazil	1978	25,000
Borror Laboratory of Bioacoustics, Ohio, USA	1945	24,000
Florida Museum of Natural History, Florida, USA	1973	15,000

Table 1 Major Sound Archives

The recordings in these archives can be used for "the description, comparison, and analysis of sounds; the identification of species, populations and individuals; taxonomy and systematics; playback, luring and trapping, and pest deterrence" (Ranft 456). Furthermore, both archiving and the use of recordings will direct our project.

2.3.2 Sound's Role in Bioacoustics

Humans are only capable of recognizing sound waves between 20 Hz and 20KHz. This is considered the audio spectrum (Rumsey 47). However, when using audio recording devices the microphones pick up more sounds than those within the audio spectrum. This increased range will enable the analysis of sounds collected outside the spectrum. Thus, the conclusions of these observations with the use of technology will be more decisive than those conducted in the field by ear. This is because sounds unheard by the human ear will be considered in analyses as well. Thus, the physics of sound is essential to biacoustical studies.

Figure 2 Sound Spectrum

2.3.3 Sound Producing Animals

All animals produce their own unique sound profile. They use these sound profiles in their daily interactions with their own species and the environment. On Mount Desert Island, the sound profiles of greatest interest are those of birds, marine animals, and mammals. Our project will assist the staff of Acadia in their ability to record these animals and overall increase the capacity of the park to make bioacoustics recordings. This increased capability will lead to an increased understanding of the animals.

2.4 Sound Pollution

Littering, run-off, and landfills are all significant sources of physical pollution. But the term, "pollution" extends to anything that alters the natural environment. Specifically, environmental noise can be defined as "unwanted sound that is caused by emissions from traffic (roads, air traffic corridors, and railways), industrial sites, and recreational infrastructures, which may cause both annoyance and damage to health" (Rumberg 127). The United States is a perfect example of excess noise pollution. Unfortunately, even the most natural places are becoming corrupted with unnecessary sound.

2.4.1 Acadia National Park's Sound Pollution

Acadia National Park is no exception to this trend. Acadia is home to thousands of species of flora and fauna (*NPS*). Animals such as bats, frogs, birds, and even some mammals rely heavily on sound in order to eat, reproduce, and anticipate danger. Any pollutants that affect these natural processes can be devastating to a species' survival.

Specifically, studies show that birds, such as the Dark-Eyed Junco and House Finch have changed the amplitude and frequency of their calls to accommodate the noisy environments (Laiolo 63). Many amphibians, such as frogs, are declining in population due to the increased noise conditions that make mating calls inaudible or ineffective. Bats, one of the most stressed species in today's natural world, are finding it hard to locate food due to the disruption of their echolocation faculties caused by human created sounds.

2.4.2 Alleviating Sound Pollution

There are several techniques that are currently being explored to alleviate the effects of man-made noise on wildlife.

The first technique in reducing sound pollution is to create a sound record. A sound record establishes a baseline for sounds in the area. Although easy to establish, a sound record is only applicable if the animals in the area are acoustically active, and cannot slip past the devices without detection.

The next two techniques are closely related. They both utilize recordings from a specific locale. In one case, researchers determine the population of a species in an area by the volume of sound emitted. In the other case researchers track the status of individual animals by the sound

or call the individual makes. Although both methods are cheap and effective, they can only be applied to actively vocal animals and to those that can be identified by their call.

Another approach is to compare results between animals of the same species in different locales. For example, a sparrow residing in New York City, an area with a high concentration of noise, may sing at a different frequency than one living in the Canadian wilderness (Laiolo 63).

There are drawbacks to these methods. Individual organisms' voice characteristics vary much like humans, which can sometimes cause test results to be inconclusive. At other times, calls vary with the age of the organism or the time of day or season.

In spite of these drawbacks, these techniques can be used to characterize the inhabitants of natural places. Through an increased understanding of bioacoustics, scientists can manipulate sounds of an environment in ways that are more conducive to the animal's wellbeing. For example, play back has attracted individuals to unoccupied yet suitable habitats (Laiolo 63).

2.5 Technology Used to Measure Sound

In order to gather useful data it must be collected and analyzed properly. To do this effectively, there must be hardware and software tailored to the task.

The hardware system must have the ability to record data and store it in a way that can be analyzed digitally. In this manner, patterns may be recognized and identification completed (*Field Recording Equipment Information)*. In addition, a complex microphone system is key to a successful recording device. In wilderness conditions, the ability to filter out ambient noise and wind patterns is critical. A simple tape recorder is not suitable for this task.

Current hardware systems, specifically recording systems, must have the following three characteristics. The first is having the capability to store large amounts of data. Another is the

ability to capture the sound itself, as well as the frequencies and ranges of the emissions. Finally, the data must be easily shared, so that further collaborative analysis can be completed (*Wildlife Acoustics*).

In contrast, the software that accompanies the hardware must make the data useful and applicable. Thus, the effectiveness of the software is measured by its ability to properly analyze the sounds made by the animals. For example, effective software must not only disaggregate the sounds based on their frequency, but also perform a recognition analysis of the data.

Another function of good software is the ability to store the data. The existence of Internet databases for storage of these sound files allows for the creation of a knowledge bank that can be accessed by scientists worldwide.

2.6 Education in the National Park System

Acadia National Park values education and the preservation of its land. By educating the public, the National Park service can better protect the land it values and generate a more informed public. In the published *Call to Action,* there is a section of six action points dedicated to advancing the NPS education mission. These points highlight the importance of education to the National Park System.

A Class Act 15 Help students develop a deep understanding of park resources and the relevance of parks in their lives through a series of park education programs. To do so we will adopt a class of 2016 graduates (grade school, middle school, or high school) at every national park and develop a series of fun, educational, and engaging activities culminating in the NPS Centennial in 2016.

Live and Learn 16 Provide multiple ways for children to learn about the national parks and what they reveal about nature, the nation's history, and issues central to our civic life. We will accomplish this by reaching 25 percent of the nation's K-12 school population annually through real and virtual field trips, residential programs, teacher training, classroom teaching materials, online resources, and educational partnerships.

Go Digital 17 Reach new audiences and maintain a conversation with all Americans by transforming the NPS digital experience to offer rich, interactive, up-to-date content from every park and program. To accomplish this we will create a user-friendly web platform that supports online and mobile technology including social media.

Ticket to Ride 18 Expand opportunities for students to directly experience national parks, where natural and historic settings inspire powerful learning. To achieve this we will provide transportation support for 100,000 students each year to visit national parks through collaboration with the National Park Foundation and other park fundraising partners.

Out with the Old 19 Engage national park visitors with interpretive media that offer interactive experiences, convey information based on current scholarship, and are accessible to the broadest range of the public. To that end we will replace 2,500 outdated, inaccurate, and substandard interpretive exhibits, signs, films, and other media with innovative, immersive, fully accessible, and learner-centered experiences.

Scholarly Pursuits 20 Sponsor excellence in science and scholarship, gain knowledge about park resources, and create the next generation of conservation scientists. To do so we will establish, through partner funding, an NPS Science Scholars program enabling 24 Ph.D. students from biological, physical, social, and cultural disciplines to conduct research in national parks each year.

Figure 3 Action Points from *A Call to Action*

Chapter 3: Methodology

As shown in the background section of this proposal, near-field analysis has become an integral part of nature-based research. Therefore, it was important to help Acadia in their use of near-field techniques and technology. Starting in June of 2013, the team began to assist Acadia National Park with bioacoustics research. The final goal was the education of researchers in appropriate near-field procedure and techniques. To accomplish this goal, a plan was implemented that included addressing the following:

- Near-field Analysis
- Equipment Selection
- Software Selection
- Video Tutorials

Most of the techniques and methods studied were specific to the needs of Acadia National Park. More in depth discussions of the plan are found in the following sections.

3.1 Near-Field Analysis

Acadia National Park is home to hundreds of species of birds, mammals, amphibians, and fish (*ANP*). Thus Acadia is a mecca for nature researchers. In order for nature researchers to conduct effective studies, they must adapt the best technologies and techniques. One of these techniques is called near-field analysis.

Near-field analysis involves using techniques that capture and record a small area. This allows for the targeting of specific species or even individuals. However, this specificity makes

the process very complex. To fully understand near-field analysis, an understanding of its purpose is vital.

3.1.1 Background of Phenology

Phenology is defined as the study of the timing of natural events (*UWGB).* Phenology is very important to understanding life on Earth. Due to issues such as global warming and other forms of climate change, ecological processes worldwide are shifting.

Many government agencies in the United States are attempting to study these changes. Included in these agencies is the National Park Service. The main goal of the National Park Service is to protect and share nature with the public. Therefore, it is vital for the NPS to understand how their environments and phenological processes are being altered. Near-field analysis techniques can help further this understanding.

3.1.2 Bioacoustics

Studying phenological processes is complicated. It requires examining long periods of time and analyzing data over the span of days, months, and even years. One specific near-field analysis technique for studying phenology is bioacoustics. Bioacoustics is studying the vocalizations or sounds made by animals. Depending on the sound many different types of assessment are possible.

By studying changes and patterns, phenological processes can be identified. Thus, the field of bioacoustics is very relevant when attempting to understand phenology. For example, it has been shown that birds of similar species are changing their calls to suit different habitats (Laiolo 63). Another way bioacoustics has been utilized is by recording the sounds of bird's

flight to identify when they are migrating. By comparing results from year to year, patterns and changes can be observed.

3.1.3 Phenology Methodology

Near-field analysis is very complex. But with an understanding of bioacoustics and phenology, it is greatly simplified. As a result, Acadia National Park created a methodology that outlines appropriate techniques and tools to conduct near-field research.

Entitled "Phenology Monitoring Protocol," the procedure was developed for the Northeastern Parks. It covers, in great detail, the proper way to record, analyze and report data collected while conducting near-field research. The document is lengthy; almost 270 pages long, which cover a great many areas of research.

The problem lies in its complexity. The document is a protocol, not a field guide. The breadth of knowledge that it covers makes it impractical to most users. The point of the project was to simplify this complex protocol with a series of online video tutorials. To do this, the first job was to find which sections were most critical to researchers and then make sure they were explained in a way that could be easily understood.

3.2 Equipment Selection

In near field bioacoustics research, specialized audio recording equipment is required. These devices incorporate time-lapse technology for the purpose of gathering data over an extended period of time. For this project, the Team focused upon the Song Meter SM2+

3.2.1 Song Meter SM2+

The Song Meter SM2+ wildlife-recording device from Wildlife Acoustics (*Wildlife Acoustics*) met the sound recording hardware requirements of the project. The information in this description is based on the overview of this product on Wildlife Acoustic's official website (*Wildlife Acoustics*). The Song Meter device is a weatherproof, multi-purpose, recording system comprised of two microphones, power source, memory, etc. This system records 16-bit audio on two channels and has a variable sampling rate ranging from 4 to 96 kHz. With digital high-pass and low-pass filters and a configurable threshold trigger adaptation, there is a broad spectrum of setup options.

The collection and storage capabilities of this device, allow easy programing of simple or complex monitoring schedules on a computer or on the Song Meter that operate relative to local sunrise and sunset. There are four flash card slots for data storage with up to 128GB storage using four 32GB SDHC cards or 512GB storage with four 128GB SDXC cards. Four D-size and two AA sized batteries are required to power the system, although there is a 6 or 20V power adaptor available if the user wishes to employ solar panels or motorcycle batteries for power.

The temperature parameters in which this device will operate are -4 to 185 degrees Fahrenheit. With this large temperature range, the device can operate nearly anywhere, except for cold environments reaching subzero temperatures.

The Song Meter can be set up at varying angles and in various locations. It is versatile enough to simply be hung on a tree or post. Virtually any set-up is possible so long as care is taken protect the sensitive microphones located on each side of the device.

Figure 4 SongMeter SM2+

3.3 Software Selection

The software used to analyze the time-lapse audio data is an important tool in simplifying near-field sound recordings. Two main sound-analyzing software packages were tested in a side-by-side comparison. The two software packages of choice were, Raven Pro developed by the Cornell Lab of Ornithology (*Birds Cornell*), and Song Scope from Wildlife Acoustics (*Wildlife Acoustics*).

3.3.1 Raven Pro

The information regarding Raven Pro was gathered from Cornell's official website for Raven (*Birds Cornell*). Raven Pro is a top of the line audio analysis software that is tailored for biologists and scientists working with acoustic signals. This software has birdsong recognition capability as well as the ability to provide sound visualizations in the form of spectrograms and

waveforms. Raven Pro can display multiple channels simultaneously and has multiple detectors that are able to detect target signals within a sound. Also, Raven Pro has a time axis that can display the time at which a sound occurred, making organization of the recordings simple. The Review interface on Raven allows users to view multiple zoomed selections on the screen.

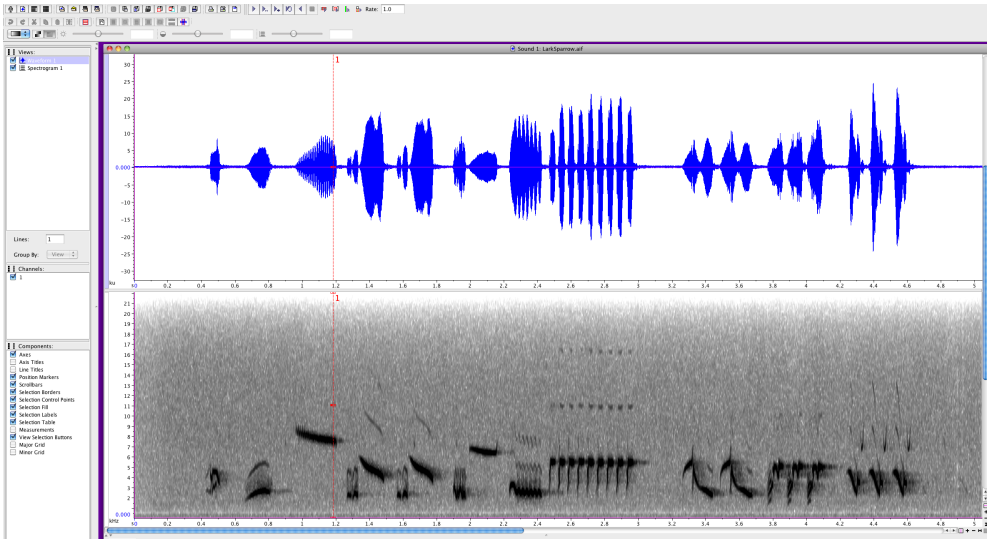


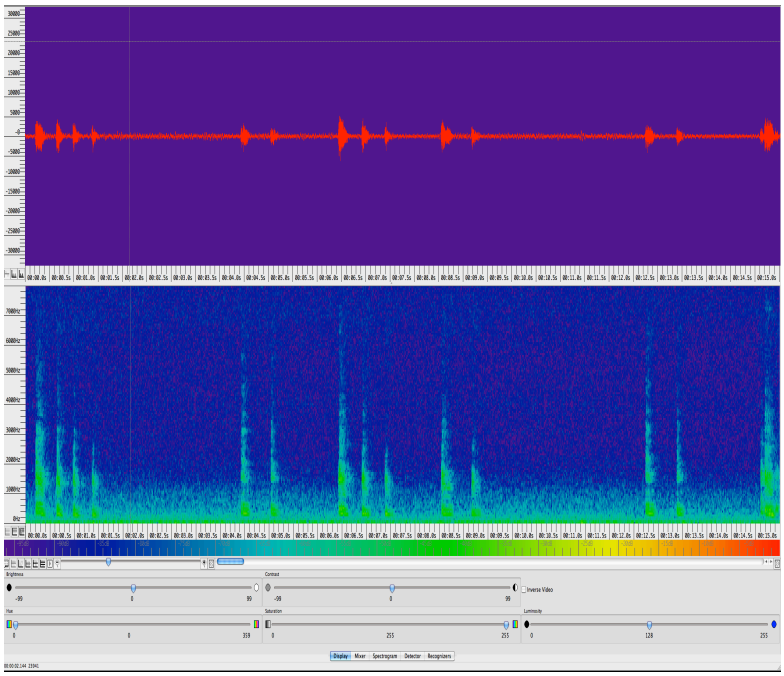
Figure 5 Screenshot from Raven Pro Software

This provides the ability to quickly review and annotate the recordings. This process of annotating is critical to the overall goal of the software. By annotating, the sound database and library are created. Classifying to species and call type only requires a single keystroke, as users are able to add single-key annotations to cells. With the ability to operate on both Windows and Mac OSX machines, Raven supports AIFF, WAV, MP3, and AIFC files on both operating systems as well as audio CD tracks on Mac OS X. For data storage, Raven Pro has the ability to acquire data to memory, to a file sequence, or to a single disk file.

3.3.2 Song Scope

Song Scope by Wildlife Acoustics is designed to work with the Song Meter SM2+;

however it will also work with any other conventional bioacoustics recording equipment (*Wildlife Acoustics*). The information regarding this software was gathered from Wildlife Acoustics official website. Employing patented classification algorithms; Song Scope automatically scans through multiple recordings looking for specific patterns of interest to the observer. Rather than manually sifting through hours of audio recordings, Sound Scope's Recognizers do the heavy lifting, sorting through lengthy audio recordings attempting to find the most likely occurrences of a specific vocalization or sound of interest. The user begins by providing Song Scope with training data, vocalizations and recordings of interest to you, in order to teach the software how to recognize vocalizations. Adding annotations to the recordings provided by the user, Song Scope analyzes the annotations and builds a recognizer that will detect and isolate similar vocalizations in future recordings. If Song Scope is provided with sufficient training data, it is typically 80 percent accurate for recognition in noisy environments for complex vocalizations. The spectrogram feature of Song Scope allows the user to sift through up to 2 GB of recordings at a time.



3.3.3 Software Comparison

The hardware's time-lapse audio data can be transferred to the computer in the form of a .wav file. From here, it is the responsibility of the analysis software to provide insight. As mentioned above, two main programs were compared in a head-to-head comparison; Raven Pro and Song Scope.

The first criteria involved how well the hardware and software worked together. The software program needed to have the ability to support the audio file type output from the Wildlife Acoustics Song Meter. It would also have to be able to read the file format off of standard recording hardware so that the programs changes could be applied to the recording. For example, Song Scope is not compatible with an .mp3 file, but luckily, the Song Meter does not record in this format.

The best references for conducting a comparison between Raven and the Song Scope software were the manuals that are published by the manufacturers. They cover every aspect of the programs and fully explain the options for analyzing data. However, the two programs differ greatly. One goal while investigating the software was to find out what the possible applications of each program were; basically, what capabilities the software had. Another goal was to see how efficiently they analyze the data. If the annotations did not provide accurate recognitions, then the software failed to complete its core purpose. Essentially, the program with the most features may not be the better program since the features might be difficult to use or may even be useless.

Another parameter for the selection of software was a balance between cost and software capability. The cost of Raven Pro is only $200 per non-commercial license (as opposed to a student license of $100 or commercial license of $400) whereas Song Scope software is $500 for

two licenses. This factor played an important part in the final recommendation to Acadia National Park, which can be found in Section 6.2.

3.4 Phenological Procedure

Relatively recently, the Park has begun to explore new near-field analysis techniques. But with these techniques comes a new set of problems. The new system of bioacoustics research still has many variations amongst researchers. Therefore, to help assist its researchers, the National Park Service created their own phonological protocol.

3.4.1 Overview of the Report

Entitled "Phenology Monitoring Protocol," the National Park Service began writing this report in 2007. It is designed to accommodate the Northeastern Parks specifically. The depth of the protocol is great as it covers almost 270 pages.

The Park Service outlines the purpose protocol with three main objectives. Its objectives are to:

1. Develop and maintain a list of key species that are of scientific or management interest and are suitable for phenology monitoring with NETN parks
2. Detect long-term trend in timing and abundance of monitored phenophases of key species at index sites in designated core and optional park habitats
3. Explore correlations between phenological data and climate variables (including mean monthly temperature and degree days) in order to develop hypotheses about impacts of climate change on phenology

The Park uses near-field procedures to attempt to accomplish these goals and outlines the proper procedure for reporting data to the Park.

3.4.2 Purpose of Review

The report covers a series of standard operating procedures (SOP's). These range in topics. A list of them is included in the table below:

Standard Operating Procedure #	Title
1	Safety
2	Site Selection and Setup
3	Observer Recruitment and Training
4	Observation
5	Building an Autonomous Recording Unit
6	Deployment and Maintenance of Autonomous Recording Units
7	Acoustic Template Creation
8	Automated Sound Detection and Classification
9	Selecting, deploying and Maintaining Automated Digital Cameras
10	Processing Image Data
11	Data Management and Quality Assurance/ Quality Control
12	Data Analysis and Reporting
13	Protocol Revision

Table 2 Standard Operating Procedures

The purpose of these SOP's was to make research as simple as possible. They cover all hardware and software needs along with important issues such as safety and site selection. However, the report does lack in certain areas. Its complexity and the general difficulty associated with near-field research make it hard to understand the document to the common reader.

Furthermore, the specificity of this paper does not suit researchers with their own procedure. For example, a researcher with their own hardware equipment would ignore SOP's 5 and 6. Thus, it would be beneficial to make a simplified version of this paper.

3.5 Video Tutorials

To help in simplifying the near-field analysis, the National Park Service developed a phenological protocol. In order to simplify the protocol for near-field researchers, a set of video tutorials were created.

3.5.1 Tutorial Topic Selection

The video tutorials needed to cover all aspects relating to the Park's use of bioacoustics near-field analysis techniques. This included both the hardware and software aspects of time-lapse audio recording. Therefore, the proposed list of tutorials was compiled.

- Hardware Set-up: Includes a detailed overview of how to set-up the Song Meter for use in the field. Items such as setting the clock, installing the batteries, and programming the hardware's recording settings will be covered.

- Song Meter Installation: Includes a review on appropriate ways to install the Song Meter in the field. This includes placement of the Song Meter, setting the Song Meter to record, and checking the data.
- Retrieving the Data: Includes information on how to remove collected data from the hardware and place it on the computer. This process is critical in order for the software to be useful in analysis.
- Using Raven Pro: Includes the method for using Raven Pro to annotate and analyze data. This particular tutorial should be broken into smaller tutorials as to keep it from being too long.
- Using Song Scope: Includes the method for using the Song Scope software to create and analyze the collected data. Like the corresponding Raven tutorial, it is broken down into smaller tutorials to shorten the length of the videos.

3.5.2 Creating the Tutorials

For the hardware tutorials, a video camera was utilized. Since the process required hands-on programming, this was the only way possible to relay the process. From here, the video clips could be loaded into the movie making software called Camtasia. The final editing process and addition of audio voice over could be done in this program as well.

For the software tutorials another program would be needed. SnagIt is screen capture software that takes a video of the computer screen while work is being completed on it. Once this video had been taken, it could be uploaded into Camtasia and the final editing process could be completed, much like the hardware tutorials.

After the completion of the tutorials, they will be posted in numerous locations on the Internet. The videos will also be given to the Park so that they can be archived and shared with researchers in the future.

3.6 Ethics

The project involved little contact between the general population and the team. However, it is important to prepare for all possible situations. In the case that the project does overlap with humans, the following precautions are necessary.

Since recording devices are used, if any people are recorded, their privacy has to be respected. No sound recordings that included human voices could be posted online. Furthermore, if any illegal activity was caught audio, they would need to be discussed with the WPI ethics board.

When setting up the hardware to capture data, there may be a chance of a violation of the Park's boundaries. Before leaving designated areas of the Park to find more secluded spaces, the Team first sought permission from the appropriate staff members.

Chapter 4: Results

Following the outlined methodology, the team was successful in gathering results that would lead to accurate analysis and conclusions. The results summary is broken down into the following categories for reporting:

- Software Analysis
- Phenology Review
- Tutorial Overview

The following sections cover each of the above points in greater depth.

4.1 Software Analysis

Two different types of software were examined; Raven Pro 1.4 created by Cornell University and Song Scope created by Wildlife Acoustics. These two were chosen because they showed the greatest potential for benefit to Acadia National Park and its researchers.

4.1.1 Raven Pro

The Raven series of interactive sound analysis software was developed by the Cornell Lab of Ornithology's bioacoustics research program. On their website, it is defined as a "software program for the acquisition, visualization, measurement, and analysis of sounds." There are three versions of Raven available for purchase. Their descriptions are found below:

- Raven Pro: a powerful research and teaching tool for scientists working with acoustic signals. Individuals conducting bioacoustics research on their own or by private groups of researchers are the main users.

- Raven Exhibit: similar to Raven Pro, but designed for use in public displays such as museums, zoos, aquariums and nature centers.
- Raven Lite: free software program that allows the viewing of sounds in the form of spectrograms and waveform plots, but is limited in analysis capabilities.

The team focused its efforts into analyzing Raven Pro since it is the most appropriate program for researchers and the National Park Service to use.

. Raven Pro has been produced in many different updates. It is currently in its fifth generation (Raven Pro 1.5). For the review, Raven Pro 1.4 was used for the sake of cost and efficiency. The cost to purchase Raven Pro for most is one-hundred dollars, although there are discounts for students and other exceptions for this rule. No programs are available for download prior to Raven Pro 1.4. The program was run on Mac OSX Snow Leopard and Windows 7 operating systems and is available for download on Linux as well. It requires only 256 MB of RAM along with the newest version of Java.

4.1.2 Strengths of Raven Pro

Raven Pro is very productive and useful software for bioacoustics research. It is simple to download and purchasing a license to run the program is very user friendly. It is perfect for researchers who are studying individually or private groups such as the National Park Service. Its design is suited perfectly to those who intend to examine sounds of any format. This includes .wav, .aif/.aiff, and .mp3, and several other lesser known file formats. Raven Pro also comes with the ability to record its own sound files directly into the program, no third party device necessary.

Opening and closing sound files is simple. Since the program is accepting of nearly every sound file format, almost any hardware is compatible with it. This includes Wildlife

Acoustics' Song Meter SM2, which was used for the majority of test recordings in this project and is found within the phenology standard written by the National Park Service. These sound files can also be altered with many different types of editing tools, such as filters. Once changed, they can be saved as .wav files of their own and used for future research.

The spectrogram and waveform plots are easily customizable. The user can manipulate the color, size, and scale of these plots with the click of a button. This feature makes it easy to examine sounds in a quantitative manner. Customizability also proves important when attempting to create analyzers and detectors.

The basic tools in Raven Pro are extensive. There are several toolbars that allow the user to explore hundreds of different commands. For example, there are many different playback options that range in variety from normal play/pause commands to a feature that lets you play your selection in reverse. The ability for Raven Pro to zoom in, cut/copy, and manipulate specific selections within a recording makes it very powerful for researchers doing frequency and amplitude analysis.

Even the more advanced tools are easily understood. Detectors are easily created and simple to understand. Programming the detector is easy to do and is a very short process, assuming a firm understanding of the type of signal that is being searched for.

The Raven system of programs comes with a catalog of thousands of species of bird sounds that are compatible with the program. This means that the spectrograms of almost all bird species can be viewed and analyzed. This library proves to be extremely useful when having to discover the parameters for creating a detector for a large data set or long time interval of recording.

When an issue arises, Cornell has developed a very effective forum that is effective at answering questions presented by users. They were also very responsive when the team sent an inquiry via e-mail and provided a thorough explanation to the question at hand.

4.1.3 Weaknesses of Raven Pro

Raven Pro, does have several flaws. The first comes from the extensive amount of commands that are available. The program's manual, although very detailed and user friendly, is lengthy. It spans over three hundred pages and it proved to be a time-consuming and tedious task in attempting to understand the full extent of the program.

The program's more advanced features come with complications as well. Annotating the selection is a complicated process to understand. The way the program works with selected sections is irascible and hard to do without a lot of practice. The detectors sacrifice accuracy for simplicity. If time and care are not taken, many false positives and missed results are possible. The researcher must be very careful when entering their data into the recognizer's parameters. The amplitude detector is almost useless when targeting land animals.

Raven also lacks the ability to run a detector over multiple recordings. Although batching is possible, this process is complicated. Thus Raven Pro proves itself to be a very effective tool for visually analyzing data, but less effective at analyzing long data sets.

4.1.4 Song Scope

A competing software product to Raven Pro 1.4, Song Scope is the other bioacoustics software that was investigated. Created by Wildlife Acoustics, it is designed specifically for animals that emit low frequency sounds. This includes birds, frogs, and marine animals. A special program is also available for bats, but this was not examined. It is defined by Wildlife

Acoustics on their website as "a powerful tool deigned to review recordings made by Song Meter or conventional bioacoustics recording equipment."

Song Scope software can be purchased online. It is compatible with all three of the major operating systems (Microsoft, Mac and Linux). The license cost is five hundred dollars. It was tested on the same computers and operating systems as Raven Pro 1.4 was.

4.1.5 Strengths of Song Scope

Song Scope's license can be purchased online with a credit card and the download of the software is quick and simple. Once downloaded, the program is very versatile. It is capable of reading .wav and .aif/.aiff file formats and Wildlife Acoustics own formats, .wac and .ssn. This range of file formats is conducive to most sound files. Since Song Scope is produced by Wildlife Acoustics, the Song Meter is also perfectly designed to work with this software.

Getting started with Song Scope is easy. The manual provided by Wildlife Acoustics is detailed, yet short enough that an amateur can work through it. At the end of this process, the user should have a total understanding of the program and all of its applications. If any complications should arise, Wildlife Acoustics has a very helpful and speedy support network that is willing and able to assist.

Song Scope has a very "pretty" view. The spectrogram and waveform plots are designed in a very effective manner that makes viewing of the data easy. It is almost self-explanatory when trying to view a sound file. Tasks like zooming, playing a specific selection, and changing the scale are simple and effective. The designers even go as far as scaling the frequencies based on a color scheme that exhibits their amplitude. For example, the loudest frequency will be scaled as red on the spectrogram whereas the softer sounds will be a darker blue.

Song Scope has several options for viewing the data on preset scales. Taking a log scale of frequencies often proves itself to be very effective for viewing data and creating recognizers (discussed later). The option to work with a selected portion of the recording also makes it possible to target certain signals that occur within a certain time period.

Annotating and viewing data is very simple. By selecting a certain section, the user is prompted through numerous parameters that may be of interest. Once saved, annotations can be hidden or shown at choice and are easily applied to long recordings.

Song Scope's greatest asset is its ability to run detectors and create recognizers. The process for creating these recognizers is extensively discussed in the manual for the program. Examples of good and bad recognizers are given. Also, they created a scale for grading the recognizers so that bad recognizers can be fixed before use.

Once created, these recognizers are extremely accurate. They can be applied to hours of recordings and yield very impressive results with very few false positives or missed signals. This ability makes Song Scope a very powerful detection tool. Recognizers can also be saved for future use so new ones do not need to be created. These saved recognizers can be applied to many recordings at the same time as well.

4.1.6 Weaknesses of Song Scope

Song Scope's software is very expensive. At five hundred dollars a seat, it is the most expensive software product that was researched. It also lacks many viewing commands and analyzing tools that some of the other software contain. In addition only one-year of updates is included in the cost. Therefore newer versions may have to be purchased in the future.

The second flaw of Song Scope is its inability to read .mp3 formats. Many types of sound files are created in this file format. For example, the Macaulay Library, the world's

largest online bird call database, keeps its files in an .mp3 format. Furthermore, recognizers are saved as an .ssn file, which is a format only usable in Song Scope. Although it is not difficult to convert from one format to another, it is still a hassle for researchers attempting to collaborate using different analysis software.

Song Scope is very specialized software. It was developed for the purpose of detection and creating recognizers. However, the creation of the recognizers is a long process. Often times trial and error is the only ways to create a highly rated recognizer. Also, the only way to make sure the recognizer is effective is to test it on data since sometimes the rating system is not an accurate description of the recognizer's ability.

4.2 Phenology Review

The Northeast Temperate Network (NETN) Phenology Monitoring Protocol is currently in peer-review by officials at several groups including the USA National Phenology Network, Acadia National Park, and Harvard University. The goal of the document is to outline a procedure for researchers conducting phenology studies when working with the National Park Service.

The entire document is broken into 13 Standard Operating Procedures that range greatly in length. Below is a table that summarizes them:

Standard Operating Procedure #	Title
1	Safety
2	Site Selection and Setup
3	Observer Recruitment and Training
4	Observation
5	Building an Autonomous Recording Unit
6	Deployment and Maintenance of Autonomous Recording Units
7	Acoustic Template Creation
8	Automated Sound Detection and Classification
9	Selecting, deploying and Maintaining Automated Digital Cameras
10	Processing Image Data
11	Data Management and Quality Assurance/ Quality Control
12	Data Analysis and Reporting
13	Protocol Revision

Table 3 Standard Operating Procedures

4.2.1 Pertinent Standard Operating Procedures

There were several Standard Operating Procedures that the team focused on. These tended to be ones that related directly to bioacoustics research. For example, Standard Operating Procedure 1- Safety was not examined closely.

As a review, the Phenology Protocol is broken up into 13 Standard Operating Procedures. These procedures range in size from 3 pages to 50 pages of information including an overview, the procedure itself, and several appendices. These appendices are usually graphs, spread sheets, or data tables that relate to procedures discussed in the section. Below are summaries of the Standard Operating Procedures that were focused upon.

4.2.1.1 Standard Operating Procedure 6- Deployment and Maintenance of Autonomous Recording Units

This Standard Operating Procedure is a lengthier one, approximately 30 pages of information and tables. It goes into details about deploying both the homemade and off-the-shelf automated recording units. Since the team had possession of a purchased ARU and for the sake of time only the off-the-shelf procedure was followed.

The Song Meter SM2+ was purchased by Acadia National Park and several are currently deployed in the interior of the Park. The phenology procedure goes into several pre-deployment details. The first is setting the time and date. This is simply completed by examining the manual. The procedure continues onto how to prepare the device physically for deployment into the field. This includes labeling the housing, adding loops to hold the device to the tree, and establishing the correct power source.

The procedure continues in detail about the correct way to schedule the Song Meter to collect the best samples. It states the best way to set the time and length of recording for different seasons of the year and also for different animal groups. Details are also included on recording settings for the Song Meter such as sampling rate and microphone set up.

Finally, there are several spreadsheets and datasheets that express recording information for both types of ARU's. This information includes but is not limited to available hours for recording, physical size of the unit, and possible storage options for data.

4.2.2 Deviations from the Protocol

The Phenology Protocol focuses its software studies on Song Scope. However, the team decided to focus its efforts on Raven Pro. Therefore, the protocol could not be followed exactly when it came to working with the acquired data.

4.3 Video Tutorials

To summarize the phenology report described above, the team was tasked with creating video tutorials. These would summarize and simplify the protocol. By making the protocol easier to understand and more readily available, phenology research in National Parks would become more efficient.

4.3.1 Tutorial Creation Method

Before the tutorials could be created, production tools were required. As mentioned in the methodology, a camera and several software programs were used. The video camera used to shoot the hardware tutorials was a Cannon Rebel.

Once filmed, the photos and video were put into a software program called Camtasia. Camtasia is available online from TechSmith for a price of fifty dollars. It is best described as video editing software. With this application the user can string video clips together and add transitions between scenes of the video. It is capable of specific animations that are conducive to video tutorials. Examples include circles and boxes to outline certain aspects on the screen, the ability to add text or numbers to the video screen, the ability to zoom in and out, and pan left and right. Camtasia also allows for outside audio to be dubbed in over recorded video. Therefore a better recorder could be used to record the audio in the tutorials. In the case of these tutorials, it was a Tascam DR-40 handheld recorder.

To capture the software-based tutorials, SnagIt was used. Also created by TechSmith, SnagIt is video screen capture software. Essentially, it has the capability to take video or still shots of a computer screen while any number of other programs or applications are running. This makes it possible to record a user actively working with the Raven Pro software, making

explanations of its features easier to understand. Once recorded, these videos can be put into Camtasia and edited the same as any other video.

4.3.2 Tutorial Topics

The tutorials created all correlate to some Standard Operating Procedure found in the NETN's Phenology Protocol. They focus specifically on the Standard Operating Procedures that relate to hardware and software usage. The following list is a finalized list of the tutorials that were created.

Tutorial Number in Sequence	Title
1	Basic Song Meter Settings
2	Song Meter Programming
3	Song Meter Pre-Deployment Preparation
4	Song Meter in the Field
5	Opening Files in Raven Pro
6	Viewing Files in Raven Pro

Table 4 Tutorial Titles

4.3.2.1 Basic Song Meter Settings

This tutorial combines information from the Song Meter's manual along with procedures from the phenology protocol. It begins with a general overview of the Song Meter SM2+. This includes a walk through of the physical attributes. Examples include the microphone location, programming button location, and the locations for insertion of batteries and memory cards.

It discusses several of the basic settings that need to be completed to prepare the Song Meter for field use. These features include the time, date, and sunrise/sunset settings. Setting the sunrise/sunset settings require a GPS location and UTC time zone conversion. Programming these functions is explained in this video tutorial.

4.3.2.2 Song Meter Programming

The next tutorial in the series discusses more advanced programming protocol. It goes into detail about how to properly set the Song Meter to record in the field. It covers both the "daily" and "advanced" scheduling settings.

The "daily" settings are very basic and easy to program, thus making them ideal for a new user. All it requires is a time, date and length of recording. The "advanced" settings can be programmed to incorporate more in depth features including more complex scheduling options and the ability to program based off of the sunrise and sunset.

4.3.2.3 Song Meter Pre-Deployment Preparation

Prior to entering the field and setting the final programming of the Song Meter, there are several final steps to be completed. This tutorial discusses those steps.

A final checklist that includes checking the batteries or external power source and also checking the memory cards is included in the phenology protocol. Thus, these steps are included in this tutorial as well. The tutorial also includes information on the recommended scheduling protocol for certain species and times of year. These pieces of information should also be taken into account before final deployment of the Song Meter into the field.

4.3.2.4 Song Meter in the Field

After final programming has been completed, the Song Meter can be physically mounted in the field. However, certain physical preparations must also be made prior to leaving for the selected site. The phenology protocol outlines a specific way to mount the Song Meter. This

includes utilizing the pre-made holes that are found in the four corners of the Song Meter housing and some relatively cheap supplies that can be purchased at your local hardware store.

The tutorial also covers the recommended way to hang the Song Meter. Once again, the phenology report includes specific details on how the Song Meter should be mounted. These were followed and recorded in the tutorial.

4.3.2.5 Opening Files in Raven Pro

This tutorial is the first that discusses software. Likewise, it was the first one to be shot using SnagIt software. It includes information on configuring sound files for viewing in Raven Pro. This includes information on opening the sound file, changing the view of the file, and the basic file formats supported by Raven. The procedure for opening these files was extracted from the Raven Pro manual from Cornell University. The phenology protocol does not cover Raven Pro.

4.3.2.6 Viewing Files in Raven Pro

Once the files have been added to Raven Pro, there are many different ways to view the files. Specifically, there are several different types of playback options that the researcher can utilize to get the best views of the data. This tutorial also describes use of basic editing tools.

Chapter 5: Conclusions

Corresponding conclusions can be drawn from the results of the project. The below sections were created to organize the conclusions. They are:

- Software Analysis
- Phenology Review
- Video Tutorials

5.1 Software Analysis

Upon finishing the examination of the two software products, the decision was made that Raven Pro 1.4 was the preferred software choice. This conclusion was drawn for several reasons.

First, the viewing capabilities of Raven Pro far exceeded the capabilities of Song Scope. The table below shows a side-by-side comparison between the software.

Features	SongScope	Raven Pro 1.4
Supported Operating Systems	Windows, Mac OS X, and Linux	Windows and Mac OS X
Supported File Types	wav, aif, aiff, and .wac (wildlife acoustics custom file format)	wav, aif, aiff, mp3, flac, canary, and audio CD tracks on Mac OS X
Supported Views	waveform, spectrogram, spectrogram slice, and log scale	multiple waveform, spectrogram, spectrogram slice, average spectrogram, and beamogram views
Spectrogram Viewing	2 color settings (color and greyscale), can change contrast and brightness	7 preset color maps, can change contrast and brightness
Correlation Features	single and batch qualitative comparison of spectrograms and waveforms	single and batch qualitative comparison of spectrograms and waveforms
Multi-Channel Audio Input Device Support	None	supports mono and stereo recording with Java Sound, multi-channel recording with NI-DAQ and ASIO devices, and multi-channel recording with CoreAudio on Mac OS X
Recording	None	Records to memory, file, or file sequence, ability to choose and configure an audio input device
Playback Features	play visible, play selection	play visible, play selection, scrolling playback, looping playback, reverse playback
Graphics	printing available	export and printing available
Amplify Feature	None	amplify selection or entire recording
Playback Rate Feature	None	Speed up or slowdown playback
Documentation	50 page step by step User's Manual	313 page User's Manual with index
Ease of use	Amateur skills required	Amateur skills required
Licensing	Single license with purchase	Single license with purchase
Price	$500	$400 (Academic, Government, and Non-Profit Research License)

Figure 7 Software Comparisons

As can be seen, there are many examples where Raven Pro's basic capabilities outperform those of Song Scope. Thus, the ability for the user to view sound files in Raven Pro is much better. This ability makes analyzing sound files in waveform and spectrogram formats much easier. Drawing conclusions from the data is much easier and more accurate.

Raven Pro is also significantly cheaper than Song Scope. For researchers who are expending their own money on equipment, this is a critical aspect. It makes more sense to purchase the cheaper software that includes better viewing features.

However, Song Scope's ability to create accurate recognizers is much greater than that of Raven Pro's. This process is long and tedious, but once completed, the detection capabilities are quite accurate. Nevertheless, this does not mean that Raven Pro is incapable of creating

recognizers. If enough time is spent analyzing frequencies and patterns, Raven Pro's detectors are also quite accurate.

5.2 Phenology Review

As mentioned previously, the phenology report produced by the National Park Service is long and in depth. By breaking the paper down into one specific Standard Operating Procedure at a time, it became easier to understand.

The team focused on Standard Operating Procedure #6, titled Deployment and Maintenance of Autonomous Recording Units. This specific procedure focuses on the Song Meter SM2 and explains the programming and deployment of this hardware. After following the procedure, it was concluded that successful bioacoustics research can be completed using the protocol. Although, this is only guaranteed with Standard Operating Procedure #6, as the other SOP's were not thoroughly tested.

5.3 Video Tutorials

Along with attempting to understand the protocol, the team created a simplification of it. Using off the shelf media production software, the team was able to create video tutorials that incorporated information from the Standard Operating Procedures.

The video tutorials are significant for two main reasons. The first being education. The National Park Service has an extensive online storage database. It houses thousands of protocols, audio files, and even video clips. By submitting the tutorials to Acadia National Park, it is safe to assume that they will also be stored for future researchers to utilize.

The tutorials are a good proof of concept. This is the second source of significance. It was possible for tutorials to be created that encompassed the scope of the Standard Operating

Procedures. Therefore, it is also possible for tutorials of a similar fashion to be made regarding the remaining Standard Operating Procedures.

Chapter 6: Recommendations

This project design was the culmination of a need for simplified instruction in phenological research. Because of this, and the fact that this was a pilot project, many changes and recommendations can be made. The original basis of this project was to create a methodology, which quickly evolved into making brief tutorials. These tutorials are the basis of the project.

6.1 Hardware

To improve the quality of the tutorials in the future, better recording hardware should be purchased. Currently in use is a Tascam handheld recorder. This device did well but when the quality of the tutorial needs to be improved the recording hardware needs to be improved as well. To do this a Large Diaphragm Condenser Microphone could be used. This type of microphone has a more detailed response and will pick up more of the voice over as it is being recorded. This will ensure a higher quality audio recording. The drawback to this microphone is that the room ambience must be controlled. To further increase the sound quality, outboard gear could be purchased. Outboard gear is a device that alters the sound input.

Many issues with sound recording during the project were due to ambient sound. No designated sound recording space was available so the living room where our iMac was located became our media production center. This location was difficult for audio recording due to the large volume of traffic around the house and also on the road next to the house. To correct this problem, a multi-media recording space should be designated with the intent of reducing ambient sound levels and increasing overall quality. If this project is done at the College of the Atlantic again, a classroom or one of the music classrooms could be utilized for this task. Another option would be to have an in house media production studio at Acadia National Park's headquarters. This option would allow the park to create tutorials at their discretion (*B&H Photo-Video-Pro Audio*).

6.2 Software

The software used over the course of this project to create the video tutorials was very helpful. For future continuity, it would be recommended to follow the same outline as the present tutorials by using the same software. The applications used were SnagIt and Camtasia. SnagIt is a video and photo screen capture tool that allows the user to designate the area and length of time of the screen capture in video mode. Camtasia is a video editing, annotation, and production tool used to achieve a polished final product. Within Camtasia the user can add transitions and effects to audio, video, and photos. Features such as zoom and pan were key in the creation of our tutorials and are easily added to video in Camtasia.

6.3 Accessibility

Accessibility is key in the continual existence of our tutorials. If the tutorials are not housed in a manner which makes them available to researchers and citizens alike then we cannot

expect them to survive over a long period of time. During the course of this project accessibility was achieved through various social media outlets such as twitter and YouTube. To improve this, the near-field Google sites website should be maintained for easy access to all social media through links on the site, however, the accessibility needs to be expanded. To expand different means should be explored.

The first place the tutorials should be expanded to is IRMA. IRMA stands for Integrated Resource Management Applications and is the National Park Service's database. By housing the tutorials here, the government employees will have easy access to the tutorials in the event of the social media platforms shutting down.

Another option would be to create podcasts for downloading off of iTunes. Within Acadia National Park, Internet access in limited. This makes watching the tutorials in the field impossible without a prior download. Therefore downloading a podcast at home or in the laboratory would insure that the tutorials could accompany the researchers in the field even if Internet access is limited. Once the tutorials are on iTunes, anyone can download them, which will greatly increase their public reach.

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